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ed, after that another, and a third near the *Pomum Adami*; by these the Bullet was discover'd, and cut out in *August 1672.*

IX. An Account of Books; viz. I. Praelectiones Chymicæ Oxoniæ habitæ a Johanne Freind, M.D., Ædis Christi Alumno.

THO' the Art of Chymistry is at present much improved, and abounds with many excellent and useful Experiments; yet it must be acknowledg'd, that hitherto there has been made but a very little Progress in the Philosophy of it; and that Men are still to seek for the Reasons of the many strange Phænomena it produces. The Chymists generally making use of such Principles as have no foundation in Nature, it is no wonder if their Philosophy is inconsistent with it self, and is neither to be explain'd or understood. On this Account the Learned Author of this Excellent Treatise, without considering the Principles and Errors of former Chymists, endeavours here to give a clear and easie Account of the chief Operations of Chymistry from the true Principles of Natural Philosophy, and chiefly that of *Attraction*; which, he says, is no Figment or *Hypothesis*, but deduced from many plain Experiments, and grounded on the Laws of Nature and that Habitude that is found among Bodies, but particularly from the Observations that are to be made in Chymistry it self. This Principle of Attraction, with several other Lemma's that are borrowed from Geometry and Mechanicks, he explains and lays down as Axioms, which are to be understood, before any Progress can be made in the Science of Nature.

Nature. And because Chymistry is an Art of joyning Bodies that are separated, or separating such as are joyned, he divides the Operations of Chymistry into two sorts; *viz.* such as disunite the Parts of Bodies from one another, and such as compound or mix them together. The Chymists not agreeing what are to be put in the second Class and what in the first, he follows a new Order, and among the first Class he reckons *Calcination, Sublimation and Distillation;* in the second are ranked *Fermentation, Digestion, Extraction, Precipitation and Crystallization.*

His design in this Treatise is to explain first, The Method of each Operation according to this Order, and the Mechanical force by which it is produced. Secondly, The different ways by which it commonly is, or may be performed: And Thirdly, He gives us many particular Experiments, which he explains and reduces to the General Theory laid down at first. Accordingly we have here the reason of the Cohesion of Bodies, which he draws from the Principle of Attraction, and the quantity of Contact; the Causes of Fluidity and Liquation; the reason why some bodies, as Wax and Metals, being melted in the Fire, and afterwards cooled, do return to their first Form, whereas others by Fire acquire a new one: How it comes about, that the absolute weight of Bodies is generally after Calcination increas'd, and the Specifick Gravity diminish'd. We have also the reason, why Fluids rise in an Alembick; and he shows that if a Globule of Water be so rarified, as to have its Diameter made only ten times greater, it will become lighter than the Air, and consequently must rise up in it: But if the Diameter be encreas'd in the proportion of 12 to 1, the Bubble of Water becomes more than twice as light as our common Air, and must therefore rise so much the faster. Besides this, the Air itself being rarified must necessarily rise up, and the force of its motion car-

ry with it what Bodies it meets with in its way ; which will more easily ascend according as their Surfaces are greater in proportion to their weight. And our Author tells us, that if the Specifick weight of Bodies, the force that impels them, and the measure of their Surfaces be rightly consider'd, it will be no hard matter to give an account of Volatility and Fixedness, and all the appearances of Distillation and Sublimation ; in which last only solid Bodies are raised by the force of Fire.

In his Lecture on Fermentation, he deduces the cause of Ebullition and Effervesce from the attractive force of the Particles of Matter, and particularly those of Salts, which he says are very simple and small Bodies, and in proportion to their bulk very solid, and must of consequence be endowed with a very strong attractive Power. Upon which account, and that of the smallness of their force of Cohesion, he shows the reason why they are so easily dissolved into Water, and not in Spirit of Wine ; as also why Water can only dissolve a certain proportion of these Salts, so that whatever quantity greater than this is immersed in Water, remains undissolved.

The Solution of all other Bodies is to be deduced from the same Principles ; but to understand them rightly, it is necessary to estimate the widenes of the Pores of these Bodies, the force by which the Parts cohere together, and the efficacy or force of motion in the Parts of the Menstruum ; which last arises from the difference of attractions of the Particles of the Menstruum to one another, and to the Parts of the Body, and from their elasticity. And upon these Grounds he explains the various Phœnomena of Dissolutions ; particularly of that hitherto unaccountable one of *Aqua Regia* dissolving *Gold*, but not *Silver*, whereas *Aqua Fortis*, of which the *Aqua Regia* is made, dissolves *Silver* but not *Gold* ; which he illustrates and reduces to a plain Calculation.

In the Lectures on Digestion and Extraction, he shows that there is a Tenacity in all Fluids, by which their Parts do in some measure cohere together, and hinders their Effects from being the same as in a perfect Fluid. He gives us the method of estimating this Tenacity, and of finding out the proportion it may have to the weight of other Bodies; and from thence he explains how small Particles of Matter, that are either specifically lighter or heavier than the Fluid, may be sustained in it, which he explains by a Calculation; and shows, that if the Gravity of the Body be to the Tenacity of the Fluid as P to 1, if the Body be divided into Parts, whose Diameters are to the Diameter of the whole as 1 to P, then these Bodies may be sustained in the Fluid, tho' specifically lighter than themselves.

He observes, that Tinctures made by Digestion are usually very strong, and saturated with the Body whose Tincture is extracted; but if the Tincture be distilled in an Alembick, the Menstruum generally rises with its former colour and clearness, leaving the Body behind it: The reason of which he explains.

He considers the several Preparations of Opium, and condemns such as are made by the fumes of Sulphur, or by acid Liquors; in which either the vertue of the Opium is lost, by the evaporation of its Volatile Particles, or destroyed by acid Salts, whose qualities are directly opposite to that of Opium; the one coagulating or making the Blood viscid, whereas the other attenuates it, and renders it fluid: But he approves of such Preparations of Opium as are made with hot and aromatick Medicines, which heighten its Vertue; and seems to prefer Dr. Sydenham's Preparation with Canary Wine to all others.

Precipitation, he says, may be made by infusing a Liquor, that is specifically lighter or heavier than the Menstruum: For by the first the Æquilibrium that was

between

between the Gravity of the Particles swimming in the Menstruum, and the Tenacity of the Fluids, is destroyed, on which account they must sink. By the second, the Particles will be carried down to the bottom by the force of a heavier Fluid. He shows likewise, how Precipitation may be caused by infusion of Saline Menstruums, whose Salts attracting the Particles that swim in the Fluid, and cohering with them, they will form such Bodies, whose Gravity will over-power the Tenacity of the Fluid, and descend. From which Principle he deduces the reason of all Chymical Coagulations.

In Crystallization of Salts, he observes, that a great part of the Fluid, in which they are dissolved, is evaporated: On which account, their Particles coming nearer to one another, their attractive force is increased, and they will come and unite together; and because the Figures of the minute Particles of each Salt are always uniformly the same, and their attractions being stronger on one side than another, they will always cohere to one another in such sides as have the greatest attractive force. On which account they must necessarily form Bodies of certain determin'd Figures, which in the same sort of Particles are always the same.

II. An Account of Animal Secretion, the quantity of Blood in the Human Body, and Muscular Motion.

By James Keill, M. D.

THE Author of these Discourses prefixes a Preface, wherein he shows the necessity of a right Knowledge of the Principles of true Philosophy, and of the Animal Oeconomy in the Practice of Physick ; where our Skill in curing Diseases, whose Histories are known, is always proportional to our Knowledge of the Animal Oeconomy, which of it self is a considerable part of Natural Philosophy. He does indeed blame the too common Method of Philosophizing on Principles not drawn from Nature, but such as are the uncertain fictions of the Brain, whose real existence can never be deduced from Experiments. This sort of Philosopher he says, is very prejudicial to Physick : Men being generally fond of their own Productions, have not stuck to mould new Diseases to answer their Hypothesis ; so that most of the late Histories of Diseases are only Philosophical Romances ; but notwithstanding this, Natural Philosophy, and the History of Diseases must go Hand in Hand in improving the Art of Curing : And he affirms, that there is no Man that practises, but who does it on some Knowledge of the Animal Oeconomy, or some Notions of his own, which are more or less clear, according to his Skill in Natural Philosophy. He proves likewise from *Hippocrates* and *Galen*, that the Principle of Attraction of the small Particles of Matter to one another, was known to the Ancients ; the Philosophy of *Hippocrates* being built on a certain propensity which some things have to one another, whereby they attract, retain, and alter each other.

In

In the first Discourse, he proves by Observation, that both the red and serous parts of the Blood are endowed with an attractive Power ; and as in the Blood the Particles attract one another, and cohere together, so likewise do the Particles of different Fluids, that are separated from it by Secretion. He says, it is evident that some of the Fluids, that are seern'd from the Blood by the Glands, are really compos'd by the cohesion of several sorts of Particles ; for in Milk there are 3 or 4 several sorts of Substances. Urine has the same appearances, and contains perhaps more Principles, and there is no doubt but that Tears, Spittle, and Sweat are all compounded Liquors. Now if the Particles which attract one another, are still more powerfully attracted by the Fluid in which they swim than by one another, they can never of themselves separate from the Fluid ; which is the case of Salts dissolved in a large proportion of Water, and of Urine when it neither breaks nor settles : But if the Particles swimming in the Fluid are more strongly attracted by one another than by the Fluid, they must necessarily separate from it, and go into parts which will either sink, swim, or ascend in the Fluid, according to their specifick Gravity. This power of Attraction, he says, is universally difused throughout all Matter, and the real existence of it, he says, can be denied by none that will duly consider the Experiments and Reasons given by Sir I^s. N. in the Questions annexed to the Latin Edition of his Opticks ; and it seems to be the only Principle from which there can be drawn a satisfactory Solution of the Phænomena produced by the *Minima Naturæ*. And because the whole Animal Oeconomy depends upon it, he lays down in eleven Propositions so many of the Laws of that universal Attraction, with their Demonstrations, as are requisite for his present purpose ; and then proceeds to show how the Corpuscles that compose the

Secretions are formed in the Blood before they arrive at their secerning Glands : But because the Particles of the Blood returning by the Veins and attracting one another, are formed into Globules too big for any Secretion, he shows how these Globules are broken and divided in the Lungs by the force of Respiration : And from Experiments, and the Doctrine of Staticks, he calculates the pressure of the Air upon the Lungs to be equal to the weight of 100 Pound ; and because the difference between the greatest and least Gravity of the Air is $\frac{1}{10}$ of the greatest, he from thence shows how Altmatick People are very sensible of this difference, especially when they breathe thicker ; for if they perform their Expiration in half the usual time, it will make this difference equal to 40 Pound weight, which is almost equal to half the Pressure of the Air in ordinary Breathing.

He shows, in the next place, how from the great Velocity of the Blood, the friction on the Coats of the Vessels, the Impetus of the Particles on one another, and their Elasticity, there must needs arise near the Heart a strong intestine Motion in the Blood, on which depends its heat ; and by consequence near the Heart, where the Motion is greatest, the union of the Particles will be in a great measure hinder'd ; and therefore the Particles that unite first, are such as have the strongest attractive force, and such as have the least, are the last in uniting. The Particles endowed with the strongest attractive Powers, are, by his 2d Prop. the most Solid and Spherical Corpuscles ; and their quantity of Contact being the least, the Secretion they compose must be the most Fluid : Such is the Liquor in the *Pericardium*.

Upon the same Principle, he gives the Reason of the situation of the Kidneys so near the Heart, that the Salts that are in Urine, being strongly attractive, and uniting closely

close'y with the watery Fluid, may quickly be drawn out from the Blood. The Corpuscles which are slowest in uniting, must be such as have the weakest attractive Force; which by his 2d Prop. are such as have the least Solidity, but their Surfaces most extended; and therefore Corpuscles, which have plain Surfaces, are longer in uniting than the Spherical ones; but when united, they cohere most strongly by his 9th Prop. and compose the most viscid Fluids: Such are the Mucilages of the Joints, which are separated at the greatest distance from the Heart.

Tho' the Secretion of the Gall by the Liver, and of the Seed by the Testicles, may seem to be considerable Objections against this Doctrine, yet there is really nothing that more illustrates and confirms it than the manner of forming these Secretions. Had the Blood been immediately convey'd by the Celiack Artery to the Liver, it is evident, that on the account of the nearness to the Heart, and the Intestine motion of the Blood, that so viscid a Secretion, as the Gall is, could never have had time to have been formed in the Blood, and secered in that place; and therefore here Nature is forced to change her constant Course of sending Blood to all Parts by the Arteries, and forms a Vein, by which the Blood is derived to the Liver from the Branches of the Mesenterick and Celiack Arteries, after it has passed through all the Intestines, Stomach, Spleen, Caul, and Pancreas. By this extraordinary contrivance, the Blood is brought a great way about, before it arrives at the Liver; and its Velocity being extreamly diminish'd, the Corpuscles will have time to unite and form the Gall: And here our Author calculates the Velocity of the Blood that comes into the Liver, and proves, that what comes by the Mesenterick Artery into the Porta, moves 177 times flower in the Branches of the Porta

Porta than in the Trunk of the Mesenterick Artery, and the Blood which comes from the Spleen to the Liver, moves 200 times flower in the Spleen than in the beginning of the Splenick Artery ; and from thence deduces the long sought for Uses of the Spleen and Porta : So productive is one simple truth of many others.

There is another contrivance for diminishing the Velocity of the Blood in the Testicles, which the Author explains, and shows that the Blood must be 150 times longer in passing to the Testicles the way it does, than if it had gone according to the common Course of Nature. After this the Author proceeds to explain the ways of forming other Secretions, as the . . . of the Ear, the Lymph, and Animal Spirits. He shows likewise, how from the Doctrine of Attraction the Operation of Medicines, which alter the quantity of Secretions, may be explained ; for Medicines that encrease the quantity of any Secretion, operate by uniting to and augmenting the Attractive force of the Particles, that compose the Humours to be secernd, which may be more effectually done by the Particles of one sort of Medicine than those of another, and therefore different Humours will require different Purgatives to carry them off through the Glands of the Intestines ; which Consideration will re-establish the Doctrine of Specifick Purges, which was confirm'd to the Antients by Experience and Observation, but rejected by the Moderns thro' a false Philosophy.

He proceeds after this, to show how necessary the Doctrine of Secretion founded on Attraction is, for the understanding of the Nature of Diseases ; and gives us an example in a Diabetes. He likewife explains from it some of the Symptoms of Rheumatisms, Gout, and Stone ; as also the Operations of Medicines in the Humane Body, especially the attenuaters and thickners of the

the Blood, but more particularly the Power of Mercury in the Cure of a Gonorrhœa or Pox ; which are all so easily explained by the attractive power of Matter, that now no body can doubt of the truth of a Principle so simple, which yet like a Master Key, opens the Works of very different contrivances, and discloses an Uniformity in all the Operations of Nature : So that every one may see and read the same thought and hand in the contrivance and framing of every part of the Universe.

Having given us the Method by which the several sorts of Fluids are formed in the Blood before they are separated from it, he then explains the way by which these Liquors are secernded by the Glands, and he proves, that the Orifices of all the Glands must be circular, and that they can only differ in magnitude ; and therefore all the Particles that arrive at the Orifice of any Gland, and are of a less Diameter than that of the Orifice, will enter the Gland : So that if there were no other contrivance in it, the Fluid which contains the biggest Particles, will likewise consist of all the Particles of the other Secretions ; but this inconveniency is obviated, by imagining several Tubes to arise from the side of the Canal or Duct of the Gland, whose Orifices are of such Dimensions, that they will admit only Particles, which are smaller than those that are to be secernded by the Gland ; and a great many of them arising from the sides of the Canal, throughout its whole Circumvolution, will carry back to the Blood the Particles which are of a less Diameter than those have, which are to be discerned ; so that there will at least remain in the Gland only these Particles, with such a proportion of the watry Fluid, as is necessary for the proper fluidity of the Liquor to be secernded.

In the Discourse on the quantity of Blood, he proves that the common Opinion that there are but 15 or 20

Pounds of Blood in the Body, is founded on no good grounds ; they supposing that when an Animal bleeds to death, that all the Blood in the Body runs out of the Wound, which the Author shews to be false ; for the larger the Vessel that is wounded is, the sooner must the Animal dye ; and if the *Aorta* it self were cut asunder, there would be a less effusion of Blood from it, than from a small Artery : And from this he explains the true reason of fainting on any sudden or violent Evacuation, as in Bleeding in the Arm, Copping in an Afites, &c.

By Blood he understands not only the Fluids in the Veins and Arteries, but all the circulating Liquors in the Body, they being all parts of the Blood, and separated from it by the force of the Heart, and many of them by the same force returning again : And in order to estimate its quantity, he supposes that the whole Body is nothing but Tubes or Vessels full of Blood or Liquors derived from it ; and then according to the various proportions of the thickness of the Coats of the Vessels to their Cavities, he calculates what the quantity of Blood must be ; and finds, that if the Body weigh 160 Pounds, it must at least contain 100 Pound weight of Blood.

He next considers the Velocity of the Blood, and determines it. And first he determines the swiftness by which it is thrown into the *Aorta*, which he finds to be such as will make it move 52 foot in a Minute ; and because the sum of the Section in the Branch of an Artery is always greater than that of the Trunk, the Velocity of the Blood must constantly decrease as the Artery branches. And according to the various proportions which the Branches bear to the Trunk, he calculates the Velocity at the extremities or evanescent Arteries, and finds that if the Trunk did always bear the proportion to the Branches of 41616 to 43506, the Blood

Blood would move at least four times slower in the extremities than in the great Artery. But if the proportion of the Trunk to the Branches were always 41616 to 52126, which is frequently observed, the greatest Velocity of the Blood will be to the least as 10000 is to 1.

In his Discourse on Muscular Motion, he proves that the Vesicles of each Fibre in the action of a Muscle are inflated by the rarefaction of the Blood and Spirits within their Cavities ; and explains the cause of this Inflation and Rarefaction from the Principles of Attraction : And then he shows, by increasing the number of Vesicles, and diminishing their bigness, the swelling of the Muscle may be made so little, as to be unperceptible, and the expence of Spirits very much lessened, and yet there will be the same degree of Contraction in the Muscle.

He then proceeds to determine the force of the Elastick Fluid, and its Proportion to the weight that is to be raised, according to the various degrees of Inflation : His Demonstrations here are founded on the same Principles with those of Mr. *John Bernoulli*, but more easy, and suited to the Capacity of those that are not versed in the deep parts of Geometry.

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